Swami Ramanand Teerth Marathwada University,
Nanded, Maharashtra, India.

(UGC Recognized NAAC Re-accredited 'B++' grade state university)

"Studies on Analysis of Pesticide Residues in Fruits and Biological Management of Fruit Pests"

A

Synopsis submitted to

For the degree of

Doctor of philosophy in Botany

Under the faculty of science

Submitted by

Mr. Chandrakant Dnyaneshwar Ghorband

Under the Supervision of

Dr. Saheb. L. Shinde

Professor and Research Guide

Department of Botany,

Yeshwant Mahavidyalaya, Nanded.

2023.

1. INTRODUCTION

The agriculture field is changes forcefully due to the high demand for food as the population increases. Pesticides are those substances that kill pests that eat fruits and vegetables and decrease productivity. To increases quality and quantity fruits and vegetables, they must be provided with proper fertilizers and sprayed with pesticides. There are various pesticides such as insecticides, herbicides, fungicides, and bactericides. Pesticides are classified into organic and inorganic; organic pesticides are chemical-free, including organochlorines, organophosphates, carbamates, and pyrethroids. Inorganic pesticides contain which contain copper, sulphur, ferrous sulfate, and copper sulfate**(Kaur et al., 2019).**Sulfur was the first pesticide known to humans **(International Union of Pure and Applied Chemistry, 2023).**The nature-based pesticides such as pyrethrum, derived from chrysanthemums, and rotenone, derived from the roots of tropical vegetables, were developed in the 19th century. In 2020 the study says that the number of pesticides consumed by the world would be around 3.5 million tonnes **(Sharma et al., 2019).**As per the available data, 61702 mega-tonnes of pesticides have been used in 2019–2020 in India, and Maharashtra is the leading state with 13243 mega-tonnes of pesticides used **(Government of India, 2023**). As of the year 2021, there are a total of 299 pesticides that are registered in India (**Government of India, 2023**).As per the Indian pesticide market value in the year 2020 was INR 232 billion. Farmers can spray the pesticides to achieve high agricultural yield. But on the other side, the high toxic chemical substances will be used in pesticides was very harmful and dangerous to human health (**Zahraa Hammoud et al., 2022**).The person who spraying the pesticide can inhale these pesticides indirectly, causing respiratory problems. If pesticide particles come in contact with the eyes, the person loses vision with irritation of the eyes to a certain extent.

Today, some sustainable control methods such as biological control controls use of pesticide, chemical pesticides are mostly used by farmers to control many diseases and pests (**Al Heidary et al., 2014; Shapiro-Ilan et al., 2022).** There are various types by which pesticides are detected to avoid health issues, and high pesticide-concentrated layered fruits can be avoided by consumers. There are some available artificial intelligence (AI) and machine learning (ML) techniques that are

effective (**Wakchaure et al., 2023**). Organochlorine pesticides are most commonly used by farmers in agriculture production in the developed and developing countries including India. Organochlorine pesticide has been associated with human health risk such as arthritis, skin disease, bone disorder, cancer and nerve disorder. India is the fourth largest producer of pesticides in the world after US, Japan and China. Therefore, information on pesticide residue in vegetables and fruit is very important for human health. The pesticides residues which are found soil, groundwater, vegetable and fruits; makes harmful effects on the human health. The qualitative and quantitative estimation of pesticides were done by using sophisticated instruments (Gas chromatograph and Mass Spectra (GC/MS)). (**Baride et al., 2023**). The different solvents such as n-hexane, petroleum ether, methyl chloride and acetone or ethyl acetate have been used for extraction of pesticide residue from fruits (**Coulston and Korte, 1975**). And also, acetonitrile is used for extraction of pesticides from fruits instead of Methylene chloride, which is hazardous to the environment (**Cook *et al.*, 1999; Krause and August, 1983**). Fruits play important role in the diet for maintenance of health and prevention of many diseases. A wide range of pesticides (13–14%) are spread for the production of fruits and vegetables in India **(Agnihotri, 1999).** Wide spread use of pesticides their toxic residues have been reported in various environmental matrices **(Kumari *et al.*, 1996; Frank*et al.*, 1987)** Pesticides are used in modern agriculture to increase the agricultural yield. Currently, India is the largest producer of fruits and the second largest producer of vegetables after China (FAO, 2017). Pesticides including organochlorines, organophosphorus, carbamate, phthalimide, and pyrethroid was used to prevent pest attack and diseases in fruits and vegetables in India **(Subash et al., 2018).** India is the largest agricultural pesticide consumers worldwide and is the second largest producer of pesticides in Asia (**Mathur, 1999**).

There is rise in the production and consumption of pesticides in India during last three decades. In India, 76 % of total pesticide consumption is insecticides as against 44 % worldwide. Of the total pesticide usage 45 % goes to cotton crop followed by paddy and wheat. While only 10–12 % of total pesticides are used for fruits and vegetables (**Beenakumari et al. 2003; Bhattacharyya et al. 2009**). Fruits and vegetables are very important components of the human diet they provide essential mineral and nutrients that are helpful for most of the reactions occurring in the body.

These fruits and vegetables are attacked by many pests and diseases occurs during production and storage they reduce the quality and quantity yield. In order to reduce the loss of and maintain the quality of fruits and vegetables harvest, pesticides are used together with other pest management techniques during cropping to destroy pests and prevent diseases. The use of pesticides has increase however, the use of pesticides during production often leads to the presence of pesticide residues in fruits and vegetables after harvest. (**U.S.Pujeri et al., 2015**). Recent advancement in research and development it makes help to reduce the toxicity and harmfulness of pesticides in some amount **(Chellappandian et al., 2018)**

2. REVIEW OF THE LITERATURE

Baride et al., 2015 studied that organochlorine pesticides that is present in groundwater, soil, vegetable and fruits by gas chromatography and mass spectrophotometer for the quantitative and qualitative analysis they observed that maximum number of pesticides are present in vegetables as compare to groundwater and soil. **Sharma s. s. and Kapadnis k. h. (2015*)*** determined pesticide residues from chilly and ladyfinger by using HPLC and GC-MS. They found that residue of endosulfan, carbendazim & chloropyrifos in chilly and ladyfinger from the various areas of Maharashtra. **Tanmay et al., (2023)** examined the techniques used for identification of pesticide residue from fruits and vegetables. They studied traditional laboratory methods like chromatography up to the advanced techniques such as automation by using sensors and other embedded technology and machine they can decrease the time and lower the cost of pesticide detection. In this study they can observed that ten methods that are very useful, effective and currently used globally, including traditional methods used at home. **Beenaet al., (2006)**worked on pesticide residues in fruits by using gas liquid chromatography equipped with ECD and NPD detectors and capillary columns they found that the fruits like ber, grapes and guava with the contamination of organochlorine, synthetic pyrethroid and organophosphate insecticides. They can conculcated that in all the fruit samples shows the presence of residues pesticides.

T. P. Swarnam and A. Velmurugan (2013)they canreported that pesticide residues found in vegetable from the Andaman Islands of India. They can studies

Vegetable such as brinjal, okra, green chilli, crucifers, and cucurbits collected from farmers tested for the presence of organochlorine, organophosphorus, and synthetic pyrethroid compounds using a gas chromatograph equipped with electron capture and flame thermionic detectors. The average pesticide residue found in all the vegetable was 0.108 ppm, with values ranging from 0.008 to 2.099 ppm. Multiple pesticides residues of more than one compound were detected in 34.1 % of samples containing residues. **Subhash et al., (2015)**works on to know about role of household techniques in reduction of pesticide residues in brinjal and okra. They also use GC-MS system to find out pesticide residues. The samples were clean separately with water, 2.0% NaCl, 1.0 % NaHCO3, 0.5 % acetic acid and boiling in water. By using household technique brinjal pesticides residues reduced by 29.5-99.2%, 30.2-92.1% and 65.6-99.7%, chlorpyrifos, cypermethrin and monocrotophos respectively. Whereas as okra, pesticides residues reduced by 24.5-98.9%, 27.2-92.2% and 62.4-99.5%, chlorpyrifos, cypermethrin and monocrotophos respectively. The maximum residues were reduced by boiling method (99.7%). They know boiling method was comparatively more effective than washing in dislodging the residues. **U.S.Pujeri et al., (2015)**studiedpesticide residues in vegetables BY using GCMS/MS as well as MRL values. The current study analyse that 40 residues are found in locally sold vegetables like cauliflower and cabbage. For this study, they collect 25 samples of each were analysed by GCMS/MS technique. Three (12%) out of 25 samples, contained pesticide residues of Chlorpyrifos ethyl (MRL value = 0.05, 0.068, 0.093and 0.11mg kg-1) in cauliflower and two (8%) out of 25 samples, contained residues of Confidor (MRL value = 0.046 and 0.079mg kg-1) in cabbage above MRL values**. Torress et al., (1996)** examined pesticide residues in fruit and vegetables. For this study they use Gas chromatography (GC) High performance liquid chromatography (HPLC)Supercritical fluid chromatography (SFC) immunoassay (IA). By using this technique, they can find out residues in fruit and vegetables.

Abubakar et. Al., (2018) reported that recent modifications and validation of QuEChERS-dSPE technique coupled to LC–MS and GC–MS system for the determination of pesticide and agrochemical residues in fruits and vegetables. The modification of QuEChERS-dSPE techniques in provides excellent validation parameters such as range of relative recoveries, quantitation and detection limits of

pesticides determined in various samples of fruits and vegetables**. Sanghi and V. Tewari, ((2001)** screen the pesticide residues in summer fruits and vegetables from Kanpur, India. They can study 12 commonly used pesticides on 23 commonly consumed vegetables and 12 fruits by using gas chromatography. They can find organophosphate and organochloride pesticides on fruit and vegetables samples but malathion organophosphate pesticides found maximum amount on both fruit and vegetables sample. **Mukesh etal., (2011)** works on to find out the contamination level of pesticide residues in grapes in Maharashtra by using LCMS and GCMS techniques. They can find out 171 pesticides in grapes during the winter season of 2010 & 2011.

3. OBJECTIVES OF THE STUDY

- To find pesticide residues in selected fruit samples of different places of Marathwada region.
- Analysis of pesticide residues by washing (household) system.
- Extraction of pesticides residues from fruits by different solvent system.
- Estimation of pesticides residues from fruits by using GC/MS technique.
- To study biological management of fruit pest.
- Statistical study of all approaches

4. MATERIALS AND METHODS

4.1. Collection of Fruit samples:

Samples of fruits were collected from different local market of Marathwada regions of Maharashtra state (M.S.) India. The collected sampling material will be documented in the form of photography. The collected samples will be identified by using the Flora of Marathwada Region **(Naik V. N., 1998)**.

Expected list of fruits used for the study

Sr. No.	Samples
1	Mango
2	Pomegranate
3	Papaya
4	Apple
5	Strawberries
6	Guava
7	Chikoo
8	Custard apple
9	Anjeer

10	Grapes
11	Dried Grapes

4.2. Extraction of Samples:

The collected fruit samples from the markets of different localities will be dried up and made in powder form. The dry powders will be extracted in different polar and non-polar solvents using Soxhlet's apparatus. The extract of sample will be vacuum dried and maintained for further phytochemical analysis using standard procedures.

4.3 Extraction of pesticide residues by cleaning method

4.4 Instrumental method for determination pesticide residues in fruits

4.5 GC/MS analysis

4.6 Biological management of fruit pest.

5. IMPORTANCE OF THE STUDY / SOCIETY APPLICATION:

5.1 National status

The use of pesticides increases agricultural production, increases crop protection and yield. However, the discovery this of pesticides has verry serious effect on the environment as well as human health as concerns regarding their use; So chemical pesticides has both the beneficial and harmful effect on environment and human health (**Sharma et al., 2014**). Organochlorine pesticides have been used across the world to control pests and vector-borne diseases agricultural field. There are few countries including India who are still busy in the production, usage and export of large scale of pesticides. In India approximately 16% of the total world's population is present but just less than 2% of the total landmass. Rapid increases population growth, together with achieving high yield Indian farmers ureses pesticides. The resent study reported that more than 100,000 tons of DDTs has been used in India alone, primarily for agricultural use. Approximately 2 million tons of pesticides is consumed worldwide each year, of which 24% is consumed in the USA, 45% in Europe and the remaining 25% in the rest of the world **(Abhilash and Singh, 2009).** The use of pesticides has very significant role economic benefits by enhancing the production and yield of food and fibres and the prevention of vector-borne diseases, evidence suggests that their use has adversely affected the health of human populations and the environment. Pesticides have been widely distributed and their traces can be detected in all areas of the

environment (air, water and soil etc.). India is one of the major roles in organic pesticide distribution. So, the health impacts of persistent organic pesticides, the regulatory measures for persistent organic pesticides, and the status of India's commitment towards the elimination of persistent organic pesticides**. (Yadav et al., 2015)**

5.2 International status

Mac Loughlin et al., 2018 works on the presence of pesticides in fruits and vegetables in Argentina. Only three of the major marketplaces there have the necessary infrastructure to determine pesticide residues in produce. They investigate the presence of such pesticide's residues in nationally produced fruits and vegetables for domestic consumption in order to evaluate the present state of the market. A total of 135 of the most widely consumed fruits and vegetables were analysed for 35 pesticides. For this work they use a *QuEChERS*™ multiresidue-extraction kit along with tandem gas chromatography–mass spectrometry. They found that according to maximum residue limits for each commodity and pesticide according to national regulation. Pesticides were detected in 65% of the total samples, in 44% of the positive samples at or below the MRLs, and in 56% above the MRLs. **Olisah et al., (2020)** reported that the use of organochlorine pesticides essentially for the control of insects and the cultivation of food crops, has led to the pollution of ecosystems. Despite being banned several years ago in the developed world, extensive use remains ongoing on the African continent. Their work found that occurrence, distributions, sources, and trends of OCPs in seven environmental matrices (atmosphere, water, sediments, soils, biota, human fluids and food products) **Syed et al., (2014)**examine to assess and analyse levels of different pesticides in selected fruits and vegetables from Pakistan. They find that more than 50 % of the samples were contaminated with organophosphate, pyrethroids and organochlorine pesticides. They reported that among fresh fruits and vegetables tomato, apple, melon, mango, grapes, and plum crossed the FAO/WHO permissible limits for these contaminants pesticidal residual levels. They compare of other regions showed that observed levels were found above maximum residue limits (MRLs) in 50 % of the samples but were in agreement with the studies from neighbouring countries like China and Bangladesh.

6. SIGNIFICANCE OF THE STUDY

Pesticides are widely used in food production in the agriculture field to increase food security but on other hand ii has negative health effects on consumers. Pesticide residues have been found in various fruits and vegetables both raw and processed material. One of the most common routes of pesticide exhibition in consumers is through the food consumption. To overcome this problem foods are consumed after passing through various processing treatments. In the study noted that the general methods of reduction or concentration of pesticide residues by certain methods of food processing for a particular active ingredient. Reduction of pesticidal residue levels was indicated by boiling, canning, frying, juicing, peeling and washing of fruits and vegetables with an average response ratio ranging from 0.10 to 0.82. Baking, boiling, canning and juicing indicated both reduction and increases for the 95% and 99.5% confidence intervals. **(Keikotlhaileet al., 2022).**

Food safety is an area of growing worldwide subject concern with the human health. The presence of harmful pesticide residues in food cause negative effect on the consumers health well environment. Hence, world take over to food safety issues, organic farming is being propagated. However, due to several reasons, diffusion and acceptance of this approach in developing countries has been very slow. Therefore, it is important in the transient phase that some pragmatic solution should be developed to tackle this situation of food safety. Food processing treatments such as washing, peeling, canning or cooking lead to a significant reduction of pesticide residues. In this background this paper reviews the common food processing operations along with the degree of residue removal in each process. The working in this serious issue is very important to reduce in the pesticidal residue levels in the prepared food, particularly through washing, peeling and cooking operations. **(Kaushik et al., 2009**).

7. PROPOSED WORK PLAN / FORMULATION AND STRUCTURE OF THE STUDY:

Year-wise Plan of work and targets to be achieved

First year

1. Referencing work.
2. Collection of fruit material from different localities.
3. Preparation of plant material for laboratory work.

Second year

1. Preparation of powder.
2. GC-MS Analysis. (Extraction and identification of pesticides)
3. Pesticides analysis.

Third year

1. Biological control of fruit pest.
2. Data analysis of all the approaches.
3. Preparation of research report, papers and articles
4. Submission of thesis

8. EXPECTED OUTCOME

Biological control is a form of pest control that uses living organisms (parasitoids, predators, or herbivorous arthropods) to suppress a pest′s density to lower levels. There are four kinds of biological control, two of which – classical biological control and augmentative biological control – are discussed in this article and two others – conservation biological control and biopesticides.

Classical biological control is the deliberate importation and release of new species of natural enemies with the intention of suppressing the densities of a target weed or insect permanently over the whole of its range in the country receiving the natural enemies. Target pests are typically invasive species and the introduced natural enemies are those specialized agents that attack it in its native range. Classical biological control is a major tool in reducing impacts of invasive species, both in crops and natural areas.

Augmentative biological control is pest suppression in greenhouses or outdoor crops through the purchase and release of commercially reared natural enemies. This approach is used against pest insects and mites, but not against weeds. Natural enemies used include both predators and parasitoids. The value of this approach depends on efficacy and cost of the natural enemy. This approach is most effective in greenhouse crops.

Biological control has important advantages compared to other methods of pest control. Classical biological control is often cheaper and less polluting than use of pesticides, because pest control is relatively permanent and does not require annual retreatment. Initial costs of classical biological control are high, for discovery, importation, testing, and initial release of new natural enemies. However, costs drop to low or even zero levels in later years, while the benefits of the pest control achieved continue to accrue for years. For augmentation biological control, results are temporary and costs reoccur annually, as with pesticides. Augmentative biological control may be either more or less expensive than other approaches depending on details such as the cost of natural enemy production by commercial insectaries that sell beneficial organisms, and efficacy of other control tactics. Both of these types of biological control are harmless to people and vertebrates, giving the approach a distinct advantage over pesticides, which must be actively managed for safe use to mitigate harm to humans and other nontarget organisms. Risks of both augmentative and classical biological control to nontarget insects or, for weed biocontrol projects, to plants can exist, but these risks can be managed to low levels by careful screening of species being considered for release in new areas. Biological control as a scientific endeavour has a history of about 125 years of effective use (beginning in the 1880s), over which time new information, techniques, and technologies have increased our ability to use biological control agents with increasingly greater understanding and effectiveness.**9. REFERANCES**

1. Agnihotri, N. P. (1999). **Pesticide safety evaluation and monitoring** (pp. 13–14). *Division of Agriculture Chemicals. New Delhi: Indian Agricultural Research Institute*.
2. Andersson, A. (1992). **The Swedish control of pesticide residues in fruits and vegetables.** In *Residues de plaguicidas: actas del II*

SeminarioInternacionalsobreResiduos de plaguicidas: Almería, Noviembre 1991 (pp. 43-58). Instituto de EstudiosAlmerienses.

3. Baride, M. V., Patil, S. N., &Golekar, R. (2015). **Estimation of pesticide residues in soil, ground water, vegetables and fruits: A case study of Jalgaon district, Maharashtra (India).** *SRTM University's Research Journal of Science. Spl. Vol*, (1).
4. Chandra, S., Kumar, M., Mahindrakar, A. N., & Shinde, L. P. (2015). **Effects of household processing on reduction of pesticide residues in brinjal and okra**. *International journal of advances in pharmacy, biology and chemistry*, *4*(1), 98-102.
5. Chellappandian, M., Vasantha-Srinivasan, P., Senthil-Nathan, S., Karthi, S., Thanigaivel, A., Ponsankar, A., Hunter, W.B., 2018. **Botanical essential oils and uses as mosquitocides and repellents against dengue**. Environ. Int. 113, 214–230.
6. Cook, J., Beckett, M. P., Reliford, B., Hammock, W., & Engel, M. (1999). **Multiresidue analysis of pesticides in fresh fruits and vegetables using procedures developed by the Florida Department of Agriculture and Consumer Services**. *Journal of AOAC international*, *82*(6), 1419-1435
7. Coulston, F., and F. Korte, 1975. **Environmental Quality and Safety: Supplement.**1stedtn.,Thieme, New York, ISBN: 0122270622.
8. El-Sheikh, E. A., Ramadan, M. M., El-Sobki, A. E., Shalaby, A. A., McCoy, M. R., Hamed, I. A., Ashour, M. B., & Hammock, B. D. (2022). **Pesticide Residues in Vegetables and Fruits from Farmer Markets and Associated Dietary Risks**. *Molecules(Basel,Switzerland)*, *27*(22),8072.https://doi.org/10.3390/molecules27228072
9. Frank, R., Braun, H. E., & Ripley, B. D. (1987). **Residues of insecticides, fungicides, and herbicides in fruit produced in Ontario, Canada,** 1980–1984. *Bulletin of environmental contamination and toxicology*, *39*, 272-279.
10. Government of India, 2023 Ministry of agriculture & farmers welfare, Department of agriculture, cooperation & farmers welfare, Directorate of plant protection, quarantine & storage. Consumption of chemical pesticides in various states/uts during 2016–17 to 2020–21.

link:http://ppqs.gov.in/sites/default/files/1.statewise_consumption_of_chemical_pesticides.xls.

11. Government of India, 2023 Ministry of agriculture & farmers welfare, Department of agriculture, cooperation & farmers welfare, Directorate of plant protection, quarantine & storage. Insecticides/pesticides registered under section 9(3) of the insecticides act, 1969 for use in country an on 01.07.2021. link:http://ppqs.gov.in/sites/default/files/insecticides_registered_under_section_93_as_on_01.07.2021.pdf
12. Hammoud, Z., Abada, M.B., Greige-Gerges, H., Elaissari, A., Jemâa, J.M.B., 2022. **Insecticidal effects of natural products in free and encapsulated forms: an overview**. J. Nat. Pestic. Res., 100007.
13. International Union of Pure and Applied Chemistry, 2023 link:http://agrochemicals.iupac.org/index.php?option=com_sobi2&sobi2Task=sobi2Details&catid=3& sobi2Id=31.
14. Jansson, C., Pihlström, T., Österdahl, B. G., &Markides, K. E. (2004). **A new multi-residue method for analysis of pesticide residues in fruit and vegetables using liquid chromatography with tandem mass spectrometric detection.** *Journal of Chromatography A*, *1023*(1), 93-104.
15. Kaur, R., Mavi, G. K., Raghav, S., & Khan, I. (2019). **Pesticides classification and its impact on environment.** *Int. J. Curr. Microbiol. Appl. Sci*, *8*(3), 1889-1897.
16. Kaushik, G., Satya, S., & Naik, S. N. (2009). **Food processing a tool to pesticide residue dissipation–A review.** *Food research international*, *42*(1), 26-40.
17. Keikotlhaile, B. M., Spanoghe, P., &Steurbaut, W. (2010). **Effects of food processing on pesticide residues in fruits and vegetables: A meta-analysis approach**. *Food and chemical toxicology*, *48*(1), 1-6.
18. Krause, R.T. and E.M. August, 1983. **Application of multiresidue method md HPLC for determining quinomethionate in apples and orange**. J. AOAC., 66: 1018-1022. PMID:6885686.

19. Kumari, B., Kumar, R., Madan, V. K., Singh, R., Singh, J., &Kathpal, T. S. (2003). **Magnitude of pesticidal contamination in winter vegetables from Hisar, Haryana**. *Environmental monitoring and assessment*, *87*, 311-318.
20. Kumari, B., Madan, V. K., &Kathpal, T. S. (2006). **Monitoring of pesticide residues in fruits**. *Environmental Monitoring and Assessment*, *123*, 407-412.
21. Kumari, D., & John, S. (2019). **Health risk assessment of pesticide residues in fruits and vegetables from farms and markets of Western Indian Himalayan region.** *Chemosphere*, *224*, 162-167.
22. Lawal, A., Wong, R. C. S., Tan, G. H., Abdulra'uf, L. B., &Alsharif, A. M. A. (2018). **Recent modifications and validation of QuEChERS-dSPE coupled to LC–MS and GC–MS instruments for determination of pesticide/agrochemical residues in fruits and vegetables.** *Journal of chromatographic science*, *56*(7), 656-669.
23. Mac Loughlin, T. M., Peluso, M. L., Etchegoyen, M. A., Alonso, L. L., de Castro, M. C., Percudani, M. C., & Marino, D. J. (2018). **Pesticide residues in fruits and vegetables of the argentine domestic market: Occurrence and quality**. *Food control*, *93*, 129-138.
24. Mathur, S. C., &Tannan, S. K. (1998). **The pesticides industry in India**. *CHEMICAL WEEKLY-BOMBAY-*, *44*, 149-160.
25. Naik, V. N. (1998). **Flora of Marathwada**. *Amrut Prakashan, Aurangabad*, *1*, 237-319.
26. Olisah, C., Okoh, O. O., &Okoh, A. I. (2020). **Occurrence of organochlorine pesticide residues in biological and environmental matrices in Africa: A two-decade review**. *Heliyon*, *6*(3), e03518.
27. Pujeri, U. S., Pujar, A. S., Hiremath, S. C., Pujari, K. G., &Yadawe, M. S. (2015). **Analysis of pesticide residues in vegetables in Vijayapur, Karnataka India**. *World J Pharm Pharm Sci*, *4*(7), 1743-1750.
28. Raikwar, M. K., Bhardvaj, V., Sawant, U., & Vora, V. (2011). **Study of Contamination Level of Pesticide Residues in Grapes (Vitis vinifera) in Maharashtra.** *The Green Pages*.
29. Sánchez, M., FISCHER, G., ACUÑA, J. F., & DARGHAN, A. E. (2019). **Pesticide residues in strawberry fruits cultivated under integrated pest**

management and conventional systems in Cundinamarca (Colombia). *RevistaColombiana de CienciasHortícolas*, *13*(1), 35-45.

30. Sanghi, R., & Tewari, V. (2001). **Monitoring of pesticide residues in summer fruits and vegetables from Kanpur, India.** *Bulletin of environmental contamination and toxicology*, *67*(4), 587-593.
31. Shapiro-Ilan, D.I., Hazir, S., Glazer, I., 2022. 12 **Entomopathogenic Nematodes as Models for Inundative. Biol. Control. Nematodes** Model Org. 293.
32. Sharma, A., Kumar, V., Shahzad, B., Tanveer, M., Sidhu, G. P. S., Handa, N., ... &Thukral, A. K. (2019). **Worldwide pesticide usage and its impacts on ecosystem**. *SN Applied Sciences*, *1*, 1-16.
33. Sharma, S. S., &Kapadnis, K. H. (1983). D**evelopment of Method for Determination of Pesticide Residues from Chilly and Ladyfinger by Using HPLC and GC-MS.** ***Methodology*.**
34. Srivastava, A. K., Trivedi, P., Srivastava, M. K., Lohani, M., & Srivastava, L. P. (2011). **Monitoring of pesticide residues in market basket samples of vegetable from Lucknow City, India: QuEChERS method**. *Environmental Monitoring and Assessment*, *176*, 465-472.
35. Subash, S. P., Chand, P., Pavithra, S., Balaji, S. J., & Pal, S. (2018). **Pesticide Use in Indian Agriculture:** Trends, Market Structure and Policy Issues.
36. Swarnam, T. P., & Velmurugan, A. (2013). **Pesticide residues in vegetable samples from the Andaman Islands, India.** *Environmental monitoring and assessment*, *185*(7), 6119-6127.
37. Syed, J. H., Alamdar, A., Mohammad, A., Ahad, K., Shabir, Z., Ahmed, H., ... &Eqani, S. A. M. A. S. (2014). **Pesticide residues in fruits and vegetables from Pakistan: a review of the occurrence and associated human health risks.** *Environmental Science and Pollution Research*, *21*, 13367-13393.
38. Torres, C. M., Picó, Y., & Manes, J. (1996). **Determination of pesticide residues in fruit and vegetables.** *Journal of Chromatography A*, *754*(1-2), 301-331.

39. Wakchaure, M., Patle, B.K., Mahindrakar, A.K., 2023. **Application of AI techniques and robotics in agriculture: a review.**Artif. Intell. Life Sci., 100057.
40. Yadav, I. C., Devi, N. L., Syed, J. H., Cheng, Z., Li, J., Zhang, G., & Jones, K. C. (2015). **Current status of persistent organic pesticides residues in air, water, and soil, and their possible effect on neighboring countries: a comprehensive review of India.** *Science of the Total Environment*, *511*, 123-137.

Signature Signature

Mr. Chandrakant Dnyaneshwar Ghorband **Dr. Saheb. L. Shinde**

(Research Student) (Research Guide)